Experimental control strategies reducing the fungicide input at a practical scale

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SUMMARY

Phytophthora infestans is the most devastating disease in potato cultivation. Chemical control is necessary to ensure a healthy crop. At the same time Dutch governmental policy asks for a reduction of the environmental impact of potato late blight control by 75% in 2012 as compared to 1996-1998. The aim of the experiments was to compare Decision Support Systems with different approaches to blight risk management for their ability to reduce the fungicide input without compromising control efficacy.

Considerable savings, up to 81% when compared to weekly, full dose rate, spray schedules, can be achieved by using information on cultivar resistance, length of the critical period and disease pressure to decide whether or not to spray. The subroutine calculating the potential for viable transport of spores is only effective on resistant varieties as the threshold was exceeded with every critical period on less resistant cultivars.

Implications of the experimental control strategies for agricultural practise are discussed.

KEYWORDS:

Solanum tuberosum; potato; late blight; *Phytophthora infestans*

INTRODUCTION

Phytophthora infestans is the most devastating disease in potato cultivation. Chemical control is necessary to ensure a healthy crop. At the same time Dutch governmental policy asks for a reduction of the environmental impact of potato late blight control by 75% in 2012 as compared to 1996-1998. Fungicide choice (Schepers *et al.*, 2009) and reduced dose rates (Evenhuis *et al.*, 2009) contribute directly to reduce the environmental impact. Additionally, the goal can be achieved by using resistant cultivars and by increasing the efficacy of the fungicide applications by:

- matching operational requirement and fungicide characteristics
- using reduced dose rates on more late blight resistant cultivars (Spits *et al.*, 2009)
- matching of the spray timing with potential infection events considering
    - potential infection events in the near future
    - the atmospheric ability for viable transport of sporangia (Skelsey *et al,* 2009a and 2009b)

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MATERIALS AND METHODS

Treatments
Field experiments were carried out at 5 locations (Table 1). Spray application were carried out according to Decision Support Systems ProPhy provided by Agrovision, Plant Plus provided by Dacom and WUR-blight developed by Wageningen UR.

Table 1. *Cultivars and decision support systems used in the 2009 experiments at 5 locations in The Netherlands.*

		A	B	C	D
		Plant Plus or ProPhy	WUR - Blight 1		WUR-Blight 2
Location	Purpose	Susceptible cultivar	Susceptible cultivar	Intermediately resistant cultivar	Resistant cultivar
Lelystad	Ware	Bintje	Bintje	Agria	Sarpo Mira
Westmaas	Ware	Lady Olympia	Lady Olympia	Agria	Bionica
Valthermond	Starch	Starga	Starga	Seresta	Festien
Vredepeel	Ware	Premiere	Premiere	Hansa	Innovator
Slootdorp	Seed	Spunta	Spunta	Agria	Toluca

Potato cultivars were planted in the spring of 2009. The crop was treated according to good agricultural practise. Late blight control varied between treatments.

Decision support systems
Treatment A was sprayed according to ProPhy (Westmaas and Slootdorp) or PlantPlus (Lelystad, Valthermond and Vredepeel). According to PlantPlus a spray application was only carried out when the threshold of 200 points was reached. Advice to consider a spray application in the range between 50 and 200 points was ignored. Treatments B and C were sprayed according to WUR-blight 1 which takes the following factors into consideration:

- Spray only when critical weather is predicted and the previous spray application does not protect the potato crop sufficiently.
- Default dose rates depend on the level of resistance of the cultivar (Spits *et al.,* 2009) and are reduced to a minimum of 25% of the recommended dose rate on resistant cultivars.
- Dose rates can be reduced depending on the fungicide degradation during the predicted critical period.

Treatment D was also sprayed according to the above criteria, but on top of that disease pressure was taken in to account. A sub routine calculates the capacity of the atmosphere to transport spores viably. according to Skelsey *et al.,* (2009a, b). If this capacity is low, despite the fact that a critical period is predicted, the crop will not be sprayed.
Decision Support Systems were consulted daily and spray advice was given accordingly.

Spray application
Spray applications were carried out using a SOSEF-sprayer with Teejet XR110.04 nozzles approximately 50 cm above the foliage, or a comparable spraying device. Spray applications were carried out with a volume of 250 l/ha. Haulm killing was carried out at the end of the season, timing depending on the purpose of the potato crop.

Observations

During the growing season the foliar infection was assessed at weekly intervals. To evaluate the epidemic, the Area Under the Disease Progress Curve (AUDPC) was determined. At the end of the season the crop was harvested. Yield and tuber blight incidence were determined. The number of spray applications and the full dose rate equivalents of the spray applications were assessed. If a spray application is carried out with a 50% dose rate it is defined as 0.5 dose rate equivalents. Total dose rate equivalents are determined by adding all individual dose rate equivalents sprayed during the season.

Statistical analyses

Five experiments were carried out. Each experiment was laid out as a randomized complete block design.

Analysis of Variance (ANOVA) was performed on yield, late blight severity and tuber blight incidence based on weight, measured per experimental plot, using Genstat release 12.1 (Payne *et al.,* 2002).

RESULTS

In the south of the Netherlands two infection periods occurred in May (Westmaas) and June (Westmaas & Vredepeel), early in the season. Followed by 4 additional infection events in Vredepeel and 5 at Westmaas.

In general, late blight infection risks first occurred at the beginning of July in the north of The Netherlands (Lelystad, Slootdorp, Valthermond). On average, the number of spray applications varied little with the treatments, although regional differences occurred. In the starch potato area the number of sprays was highest, due to the long growing season. The total dose rate equivalents applied however varied considerably between treatments (Table 2). On average the dose rate equivalent decreased with 19% by just spraying to cover the critical period (B compared to A). Taking also the cultivar effect into account a reduction of 42% was achieved (C compared to A). With the most resistant cultivar also the effect of disease pressure came into the equation and a reduction of 65% was achieved on average. Even higher reduction rates would have been achieved when the spray schedules were compared to weekly spray schemes with full dose rates, varying from a minimum of 46% to a maximum of 81% reduction.

Table 2. *Full dose rate equivalents of the sprays applied according tot the different late blight control strategies. The number of spray applications is denoted between parenthesis*

		A	B	C	D
		Plant Plus or ProPhy	WUR - Blight 1		WUR-Blight 2
Location	Weekly interval	Susceptible cultivar	Susceptible cultivar	Medium resistant cultivar	Resistant cultivar
Lelystad	13	4.0 (4)	5.25 (7)	3.75 (7)	2.25 (6)
Westmaas	14	11 (11)	5.75 (7)	3.75 (7)	1.75 (4)
Valthermond	16	9.0 (9)	11.75 (15)	8.0 (15)	3.75 (12)
Vredepeel	15	4.8 (5)	5.0 (7)	4.0 (9)	2.75 (8)
Slootdorp	11	9.0 (9)	3.0 (4)	2.5 (4)	2.5 (4)
Average	13.8	7.6 (7.6)	6.2 (8.0)	4.4 (8.4)	2.6 (6.8)

No foliar or tuber blight occurred in the field during the experiments at Vredepeel and Slootdorp. Foliar blight occurred at Lelystad and Valthermond (Table 3), whereas tuber blight was found at Lelystad and Westmaas.

Table 3. *Foliar blight (AUDPC) and tuber blight as a result of the control strategies assessed, at three locations in 2009, in The Netherlands. No late blight occurred at Slootdorp and Vredepeel.*

Treatment	AUDPC						Tuber blight					
	Lelystad		Westmaas		Valthermond		Lelystad		Westmaas		Valthermond	
A	469	.b	0	a	180	.b	2.0	.b	0.06	a	0	a
B	6	a.	0	a	40	a.	0.4	a.	0.02	a	0	a
C	12	a.	0	a	14	a.	0.1	a.	0.02	a	0	a
D	0	a.	0	a	66	a.	0.6	a.	0.00	a	0	a

DISCUSSION

Considerable savings, up to 81% when compared to weekly, full dose rate, spray schedules, can be achieved by using information on cultivar resistance, length of the critical period and disease pressure to decide whether or not to spray. The subroutine calculating the potential for viable transport of spores is only effective on resistant varieties as the threshold was exceeded with every critical period on less resistant cultivars (Skelsey *et al.,* 2009a).

Late blight control was satisfactory apart from a few treatments. Plant Plus was used strictly with the threshold of 200 points. In agricultural practise PlantPlus advices to consider spraying at 50 points or above. In our experiments the 200 threshold was applied strictly, which may have caused the significant late blight development in treatment A at Lelystad and at Valthermond. Late blight control in cultivar Festien (treatment D Valthermond) lacked somewhat also. From previous experiments a dose rate reduction of 75% should still control late blight satisfactory in this cultivar (Evenhuis *et al.*, 2009). However the current late blight population might contain higher levels of virulent genotypes leading to erosion of the resistance level of cultivar Festien. Therefore it is necessary to monitor the *P. infestans* population for changes in aggressiveness an virulence.

At Westmaas no foliar blight was found, nevertheless some tuber blight occurred. Possibly some blight in the crop remained undetected. Alternatively sporangia might have been deposited on the crop after haulm killing and infested the tubers subsequently.

WUR-blight had on average no effect on the number of spray applications compared to the other Decision Support Systems. However the timing of the spray applications was much different. The WUR blight system protects the crop principally only during critical periods with a minimal fungicide input. This calls for flexibility of the farmer, since the DSS has to be consulted daily, also shortly after a spray application. In a period with high disease pressure sometimes two spray applications within a week are advised using WUR-blight, whereas in other periods long spray intervals of 30 days or more occurred. Farmers have a preference to a more or less weekly spray schedule. Strategies have to be developed in which a weekly schedule can be combined with lowering dose rates based on cultivar resistance and infection periods.

CONCLUSIONS

On average the dose rate equivalent decreased with 19% by just spraying to cover the critical period. Taking also the cultivar effect into account a reduction of 42% was achieved.

With the most resistant cultivar also the effect of disease pressure came into the equation and a reduction of 65% was achieved on average.

Compared to weekly spray schemes with full dose rates, a reduction varying from a minimum of 46% to a maximum of 81% can be achieved using WUR-blight.

In 2009 a limited number of critical periods occurred. At Westmaas, Slootdorp and Vredepeel the potato crop was not infected despite reduced and minimal fungicide input.

A low level late blight infection was found in Lelystad using WUR-blight.
A 25% dose rate proved to be too low to protect cultivar Festien sufficiently.
The modules can be further improved for future use.

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